Module and Method of Manufacturing the Module

Field of the Invention

The present invention relates to a module such as a high-frequency module for a small sized electronic apparatus such as a mobile telephone a method of manufacturing the module, and particularly to a signal electrode provided on a printed circuit board for the high-frequency module.

Background of the Invention

A conventional high-frequency module includes a substrate of substantially a four-sided shape having a recess provided in the cut side thereof, an electronic component mounted on the substrate, and a signal electrode provided at the recesses. One end of the signal electrode is exposed at the cutting sides.

The substrate is manufactured by the following manner. As shown in Fig. 18, a printed mother board 2 incorporates an array of substrates 1 for high-frequency modules. As shown in Fig. 19, each of the substrates 1 has a pattern of a signal electrode 3 provided at all the lateral sides thereof where neighbor substrates 1 are linked. Also, a signal electrode 4 is provided at each corner of the substrate 1. The signal electrodes 3 and 4 are formed through forming holes and coating the holes with copper plating functioning as through holes. The printed mother board 2 is then cut along a joint 5 to provide the substrates 1.

Since having a copper plated signal electrodes 3 and 4 cut along the joint 5, each conventional high-frequency module may have burrs developed at its edges. The burrs decline quality of the plating of each signal electrode. More specifically, when the module is mounted in a circuit assembly, the

burrs possibly is detached by adverse vibrations thus causing a short-circuit. Hence, the burrs need to be removed in an extra process by a worker.

Summary of the Invention

A module includes a substantially four-sided substrate having a recess formed at a lateral side thereof, an electrode which is provided at the recess of the substrate and has an absent portion between the lateral sides of the substrate, and an electronic component mounted on the substrate. The module has the electrode without unwanted burrs.

Brief Description of the Drawings

Fig. 1 is a flowchart for manufacturing a printed mother board according to Embodiment 1 of the present invention.

Fig. 2 is an enlarged plan view of a primary part of the printed mother board according to Embodiment 1.

Fig. 3 is a plan view of the printed mother board according to Embodiment 1.

Fig. 4 is an enlarged plan view of a first primary part of the printed mother board according to Embodiment 1.

Fig. 5 is an enlarged plan view of a second primary part of the printed mother board according to Embodiment 1.

Fig. 6 is an enlarged cross sectional view of the primary part of the printed mother board according to Embodiment 1.

Fig. 7 is a flowchart for manufacturing a high-frequency module according to Embodiment 1.

Fig. 8 is a flowchart for manufacturing a printed mother board according to Embodiment 2 of the present invention.

Fig. 9 is an enlarged plan view of a primary part of the printed mother board according to Embodiment 2.

Fig. 10 is a plan view of a region adjoining a hole of a printed mother board according to Embodiment 3 of the present invention.

Fig. 11 is a perspective view of a high-frequency module according to Embodiment 4 of the present invention.

Fig. 12 is a perspective view of a primary part of the high-frequency module of Embodiment 4.

Fig. 13 is a perspective view of a primary part of an internal layer substrate of Embodiment 4.

Fig. 14 is a perspective view showing the high-frequency module and its neighbor area according to Embodiment 4.

Fig. 15 is a plan view of the back side of the high-frequency module of Embodiment 4.

Fig. 16 is a cross sectional view of a primary part of shield case dies according to Embodiment 4.

Fig. 17 is a cross sectional view of a primary part of the high-frequency module of Embodiment 4.

Fig. 18 is a plan view of a conventional printed mother board.

Fig. 19 is an enlarged plan view of a primary part of the conventional printed mother board.

Description of the Preferred Embodiments

(Embodiment 1)

Fig. 1 is a flowchart for manufacturing a printed mother board according to Embodiment 1 of the present invention. Fig, 2 is a plan view of a primary part of the printed mother board. Fig. 3 is a plan view of the

printed mother board. Fig. 4 is a plan view of a first primary part of the printed mother board. Fig. 5 is a plan view of a second primary part of the printed mother board. Fig. 6 is a cross sectional view of the primary part of the printed mother board. Fig. 7 is a flowchart for manufacturing a high-frequency module according to Embodiment 1.

Embodiment 1 of the present invention will be described referring to the relevant drawings. A substrate used as the high-frequency module will be described at first.

As shown in Fig. 3, the printed mother board 11 incorporates an array of the substrates 12 where any two adjacent substrates are linked to each other along vertical and horizontal joints 13. Fig. 4 illustrates the substrate 12 has a signal electrode 15 provided on a link side 14 at which the substrates adjoin. It is now noted that a copper-plating-absent region 17 is wider than a cutting strip 16 along which the joint 13 is separated. This allows the signal electrode 15 to generate no burrs during the separation along the cutting strip 16.

Fig. 5 is an enlarged view of a corner joint 18 where four of the substrates 12 meet. A signal electrode 19 of each substrate 12 is provided at the corner joint 18 as shown in Fig. 5. Similar to Fig. 4, a copper-plating absent region 21 is arranged wider than a cutting strip 20. This allows the signal electrode 19 to generate no burrs during the separation along the cutting strip 20. Also, since four of the signal electrodes 19 are simultaneously provided when one single hole is drilled through the corner joint 18, the number of manufacturing processes can be reduced thus and the life of a drill used for drilling can be increased.

Fig. 6 is a cross sectional view of the signal electrode 15 manufactured by the above manner. Since the copper plating absent region 17 is wider

than the cutting strip 16, burrs are hardly produced during the separation along the cutting strip 16.

The procedure of manufacturing the signal electrodes 15 and 19 will be described in more detail referring to the flowchart of Fig. 1. The flowchart of Fig. 1 illustrates the procedure of manufacturing a printing mother board with a positive photo-resist. A through hole at a region for a signal electrode on the joint 13 of two of the adjoining substrate 12 of the printed mother board 11 (Step 25). Then, copper plating is performed at the region for the signal electrode about the hole (Step 26). The region is then coated with the resist (Step 27). The resist is then cured (Step 28). Being covered with a mask 33 shown in Fig. 2,the mother board is exposed to light (Step 29). The mask 33 has a recess 33a positioned over the signal electrode formed at a border of the two of the adjoining substrates 12. The adjoining substrates 12 are linked to each other along the joint 13. Only a portion corresponding to the recess 33a of the resist is exposed to the light and thus decomposed. Then, the decomposed portions of the resist are removed (Step 30). The copper plating at the portion where the resist is removed is removed (Step 31). The printed mother board 11 is then stored (Step 32).

Then, paste soldering is applied on the printed mother board 11 (Step 102) as shown in Fig. 7. Then an electronic component is mounted onto the printed mother board 11 (Step 103) and soldered to the substrates 12 with a reflow furnace (Step 104). On the board 11, a slit along is formed the lateral sides of each substrate 12 by dicing (Step 105). The signal electrodes 15 and 19 of each substrate 12 are electrically separated from those of the adjoining substrates 12. Water for the dicing is discharged (Step 106). The substrate 12 is then provided with power from pins of a inspecting device for examining the oscillation frequency (a first inspection) and subjected to laser

trimming to oscillate at a desired frequency (Step 107). The substrate 12 is then rinsed (Step 108) and covered with a shield case (Step 109). A mark is impressed on the shield case (Step 110). A pattern of the paste solder is transferred onto the substrate 12 (Step 111) and subjected to a reflow process to fix the shield case onto the substrate 12 (Step 112). The substrate 12 is finally examined (a second inspection) in electrical properties (Step 112). The substrates 12 are then separated from the printed mother board 11 (Step 114). The substrates 12, high-frequency modules, are loaded on a tape (Step 115) and stored (Step 116). Since the steps up to the final inspection at step 113 are carried out with the substrates 12 in the form of a worksheet, the printed mother board 11 which is not separated, the high-frequency module can be manufactured significantly efficiently.

Referring to Fig. 2, the two recesses 33a of the mask 33 are separated from each other by 180 degrees for determining the signal electrode 15 of the substrate 12. For determining the signal electrodes 19 at the corner joint 18, the mask 33 includes the four recesses 33a provided therein at an equal interval of 90 degree. In this case, the mask 33 is placed with its recesses 33a positioning above the corner joint 13 where the four substrates 12 meet. The width of the recesses 33a determines the width of the copper plating absent regions 17 and 21.

Since including the copper plating absent regions 17 and 21 (See Figs. 4 and 5) determined with the mask 33, the mother board 12 has no burrs produced during the separation along the cutting strips 13. That is, the separated regions of each substrate 12 has a better quality even by a visual inspection, than the conventional substrate having the signal electrode regions cut directly.

(Embodiment 2)

A printed mother board 11 according to Embodiment 2 is identical to that of Embodiment 1 shown in Fig. 3 through Fig. 6, but different from it in a manufacturing method.

Fig. 8 is a flowchart for manufacturing a printed mother board 11 with a negative photo-resist according to Embodiment 2 of the present invention. A through-hole is drilled at a region for a signal electrode at a joint 13 between two adjacent substrates 12 of the printed mother board 11 (Step 35. The region about the hole is copper-plated (Step 36), coated with the resist (Step 37), and exposed to light through a mask 34 shown in Fig. 9 (Step 38). The mask 34 has the projections 34a positioned over the region for the signal electrode of the two adjacent substrates 12. The adjacent substrates 12 are linked to each other along the joint 13. Thereby, the resist is removed except portions corresponding to the projections 34a of the mask 33 is exposed to the light and thus cured. The uncured portions of the resist protected with the projections 34a are removed by etching (Step 39). The copper-plated portion covered with no resist (corresponding to the projections 34a) is also removed by etching (Step 40). The printed mother board 11 is stored (Step 41). A method of manufacturing a high-frequency module is identical to that of Embodiment 1 described with Fig. 7.

As shown in Fig. 9, the projections 34a of the mask 34 for manufacturing the printed mother board 11 are separated from each other by 180 degree for determining the signal electrodes 15 of the substrates 12. For determining the signal electrodes 19 at the corner joint 18, the mask 34 has four of the projections 34a provided at an equal interval of 90 degree. In this case, the mask 34 has the projections 34a positioned along the joint 13 between the substrates 12. The width of the projection 34a determines

the width of the copper plating absent regions 17 and 21 of the signal electrodes 15 and 19. Since the copper-plating-absent regions 17 and 21 (Fig. 4 and Fig. 5) are determined by the shape of the mask 34, burrs is hardly produced during the separation along the joint 13. Edges at the signal electrode have significantly improved quality compared with the conventional substrate even by a visual inspection.

(Embodiment 3)

Fig. 10 is an enlarged plan view of a primary part for explaining a method of manufacturing a signal electrode 52 provided along a joint 51 between two substrates 50. Along the signal electrode 52, a row of round holes 53 to 57 each having a radius R is formed at an equal distance R. The radius R of the round holes is 0.5mm in this embodiment. The round holes may be formed by drilling. It is also noted that the round holes are drilled alternately. For example, the round hole 53 is drilled, then the round hole 55 and the round hole 57 are drilled. Then, the round hole 54 and the round hole 56 are drilled. Thereby, centers for the drilling remains not diverted, hence being locating the round holes accurately.

A shield case has a leg 58 placed over the substrate 50 and forming a space 59 between the signal electrode 52. The space 59 between the signal electrode 52 and the leg 58 is filled up with a solder paste by a capillary action, thus improving enabling the case to be soldered securely.

(Embodiment 4)

A high-frequency module manufactured by the method of Embodiments 1 to 3 will be described. The module includes a substrate 62 identical to a substrate 12 described in Embodiments 1 to 3.

Fig. 11 is an external perspective view of the high-frequency module 60. The high-frequency module 60 includes the substrate 62 having substantially a four-sided shape, a recess 64 provided in a cut side 63 of the substrate 62, a signal electrode 65a provided in the recess 64, an electronic component mounted on the substrate 62, and a shield case 66 for shielding the electronic component. The signal electrode 65a has an end 67 separated from the cut side 63 by an absent distance 68 of an insulator (air in the present embodiment).

Since the absent distance 68 of the air provided between the end 67 and the cut side 63 allows the signal electrode 65a to be intact during the separation of the substrate 62 from a mother board, thus producing no burrs. The signal electrode 65a, since being provided in the recess 64, is hardly polluted during handling. Also, the overall mounting area of the module can be reduced.

The signal electrode is classified into a large size 65a and a small size 65b. The large size signal electrode 65a may be used for grounding, and the small size signal electrode 65b may function as ordinary signal electrodes. If being not classified, the electrodes may be sized identically

Fig. 12 is a perspective view of a region 65 for the signal electrode. The region 65 consists of a land 70 mounted on upper and lower sides of the substrate 62. Upon having the signal electrodes connected at the lower side of the substrate, the module can reduce the overall size of a device including the module mounted thereto.

Fig. 13 illustrates a substrate 62 of this embodiment having a multi-layer construction. As shown, the substrate 62 includes an internal layer 72 in the printed mother board, a worksheet form, before separated into the substrates 62. A pattern on the internal layer 72 of the substrate 62 is

connected to a land 73 connected to region 65 for the signal electrode with a through hole. The signal electrode 65 is separated along a cut line 63. The cut line 63 is spaced by an absent distance 74 from the land 73. The absent distance 74 allows the substrates 62 in the worksheet form to be inspected prior to the separation. That is, the signal electrodes 65 of any two adjacent substrates 62 in the worksheet form are electrically isolated from each other, and thus, signals to them can be separated without a dummy substrate.

Fig. 14 is a perspective view of the substrates 62 in the worksheet form. Since having five signal electrodes 65 on each cut side 63 thereof, the substrate 62 form a high-frequency module having various functions. The signal electrodes 65 are prevented from undesired burrs.

Since being provided on all the four lateral sides of the substrate 62 of substantially a four-sided shape, the signal electrodes 65 are electrically isolated from each other despite small dimensions of the substrate 62. Therefore, the electrode provides the high-frequency module designed flexibly in patterns, and the module provides an apparatus with an significantly-reduced overall size.

As described in Embodiment 3, the large-sized signal electrode 65a in the recess 64 of the substrate 62 for grounding is formed with a series of drilled round holes as a second recess extending from the upper side to the lower side of the substrate 62. Thus, the electrode 65a can preferably be formed by a simple drilling process. A shield case 66, upon being placed over the substrate 62 before soldering, has a leg 66 creat a space between the signal electrode 65a. The space, upon being filled with soldering paste by a capillary action, allows the leg 66a to be soldered securely to the signal electrode 65a.

Since including the substrate 62 covered with the shield case 66

connected at the legs 66a to the signal electrode 65a for grounding, the high-frequency module is handled easily, receives and transmits little noise between the outside.

The signal electrode 65 of the substrate 62 and the leg 66a of the shield case 66 will be explained.

Fig. 15 is a plan view of the high-frequency module including the substrate 62 and the shield case 66 soldered to the substrate 62. The horizontal and vertical sides of the substrate 62 in the drawing are determined with the cut line 63. In this embodiment, the cut lines, i.e., sides 63 of the substrate 62 are spaced by a gap 81 of 0.07mm to 0.15mm from the leg 66a of the shield case 66. In other words, the cut side 63 projects by the gap 81 from the leg 66a of the shield case 66. This protects the shield case 66 from being injured by a cutter during the separation of the substrates 62 from the printed mother board, the worksheet form. If the gap is too small, the lateral sides of the shield case 66 may be injured during the separation. Also, the cut sides 63, if being located more outward, increases the overall size of the high-frequency module.

Since the shield case 66 is placed over the printed mother board as the worksheet form, a pattern of paste solders 82 are transferred onto the back, lower side of the mother board. After the soldering, the remaining spot 82a of the paste solder 82 are deposited on the land 70 of the substrate 62.

As described in above, the shield case 66 has the leg 66a soldered to the signal electrode 65. The cut sides 63 of the substrate 62, since extending more outward than the leg 66a of the shield case 66, protect the solder between the leg 66a and the signal electrode 65 from external stress thus providing no crack with the solder.

A modification of the shield case 66 on the substrate 62 will be

explained. The shield case 66, upon having an outer surface roughened, has a surface area increase. This improves a property for heat radiation, and therefore, enables the shield case 66 to reduce an influence from heat developed from the component on the substrate 62. The shield case 66 may have the lateral sides roughen with a dicing cutter during the separation of the substrate 62. This allows the cut side 63 of the substrate 62 not to project outward from the lateral side of the shield case 66, thus contributing to the reduction of the size of the module. Also, the dicing process can simultaneously conduct two different steps, the separation of the substrates 62 and the roughening of the shield case 66, hence eliminating an extra roughening step. The roughening may be applied to all the lateral sides or one particular lateral side. As long as the upper side is not roughened, the module can remain not declined in the appearance.

The shield case 66 is manufactured from a metal sheet 86 such as tin-plated steel held on a die 85 and punched out into a shape with a punching die 87. The punching may produce burrs on the edge of the metal sheet 86, as shown in Fig. 16. The metal sheet 86 is then bent in the direction of the punching to form a bent 66b as shown in Fig. 17. The leg 66a is shaped on the bent 66b, then the shield case 66 is completed. Since the shield case 66 is joined at the signal electrode 65 to the substrate 62, the burr 88 produce a gap 91 between the side wall 90 of the signal electrode 65 and the leg 66a. The gap 91 allows the soldering paste molten by re-flow heat to be distributed uniformly by a capillary effect. The burr 88, since not extending towards the neighbor substrate 62, ensures the distance from the neighbor substrate 62 and allows the high-frequency module 60 to be safe on its lateral sides. In Fig. 17, a resistor 92, the heat generating component, is mounted on the substrate 62.

Then, the shield case 66 has the upper side provided with a mark impressed thereon. The mark, upon being made at once on an array of the shield cases 66 in the worksheet form, is produced efficiently. The mark, upon being made with laser beam, is performed at a uniform position regardless of the type of the modules, and thus offering a quality of appearance. The mark is made out with a laser beam easily at higher speed. Moreover, the mark by laser beam can remain intact when being touched by finger.

As set forth above, the substrate 62 of this embodiment is extended at the cut sides 63 outward from the shield case 66. This allows the soldered region of the shield case 66 not to accept directly any external stress or not to produce cracks. The shield case 66 is protected from being injured by a cutter for separating the substrates 62 from the printed mother board of the worksheet form.

Alternatively, the cut side of the substrate 62, upon being substantially identical to the cut strip 63, allows the high-frequency module to have a reduced overall size. This reduces a redundant portion of a pattern of a printed circuit on the printed mother board to has a redundant portion.

The shield case 66, upon being roughened on its lateral side more than its upper side, has its surface area increasing thus having an improved heat radiation. The roughening of its lateral side increasing the friction allows the high-frequency module to be held easily during the manufacturing process.